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APPLICATION OF HAPKE PHOTOMETRIC MODEL TO THREE GEOLOGIC SURFACES USING PARABOLA BIDIRECTIONAL REFLECTION DATA;

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The Geologic Remote Sensing Field Experiment (GRSFE) was conducted in July and September of 1989 to collect data with both ground and airborne instrumentation [1]. A major objective of GRSFE was to collect data which could be used to test radiative transfer models for the extraction of composition and textural surface properties from remotely acquired data. This abstract reports initial results from an application of the Hapke photometric model [2,3,4] using data from PARABOLA (Portable Apparatus for Remote Acquisition of Bidirectional Observations of Land and Atmosphere) [5].

PARABOLA is a ground based radiometer with three spectral channels centered at 0.66 μm, 0.83 μm, and 1.66 μm. The radiometer is mounted on a rotating boom and measures ground radiance in a 15° instantaneous field of view from over 70 different viewing geometries in about 11 seconds. The mechanics of the instrument do not permit the same point on the ground to be measured with each look; rather, each pixel represents the radiance from a different portion of a 35m x 35m area. To insure that the data are representative of the surface, a homogeneous section of each site is selected for the instrument to measure.

PARABOLA data were acquired in the Lunar Crater Volcanic Field in Nevada [6], specifically from the region of Lunar Lake, a playa. Several modeling sites were established in this area and data from three of these sites were collected with PARABOLA. The first site consisted of a section of the Lunar Lake playa which was characterized by a clay rich, hard packed surface with decimeter size mudcracks. The second site, called the cobble site, was similar to the playa site but was strewn with basaltic cobbles and pebbles from a nearby flow. The cobbles were centimeter to tens of centimeters in size and varied in abundance from about 25% to 85% over the playa [E.Guinness, pers. comm]. The third surface consisted of a mantled basalt lava flow. This surface was the most inhomogeneous of the three and contained small amounts of visible silt and significant vegetation in the form of bushes.

Data were acquired five times during the day from the playa and cobble sites, and six times from the lava flow. The times of data acquisition were spaced to provide a wide variety of solar incidence angles for each site, typically from approximately 20° to 70°. Periodically throughout the day, a barium sulfate plate was measured by PARABOLA as a reference Lambertian scatterer. Dividing the radiance from the surface by the radiance from the reference plate and the cosine of the incidence angle gives a measure of reflectance termed the radiance factor [2].

Radiance factors from each site were inverted to extract the Hapke parameters; single scattering albedo, roughness, opposition surge amplitude and width, and particle phase function described by a Henyey-Greenstein assymetry factor. Inversion techniques included a grid map and a grid search algorithm [7]. Initial analyses of the lava and cobble sites have only used channel 1 (0.66 μm) data. The analysis of the playa site is more complete - all three channels of data have been fit with the Hapke model. The effects of atmospheric scattering were estimated using the numerical radiative transfer model, LOWTRAN-7 [8], and found to be approximately four orders of magnitude lower than the surface reflectance, and therefore negligible.

The modeling results were mixed. The playa, although a particulate surface and the most homogeneous of the sites, could not be adequately fit with the Hapke model. At moderate incidence angles (<40°) the playa behaved as a Lambertian scatterer. At higher incidence angles (>50°), the playa displayed a strong forward scattering lobe in the solar principal plane. The presence of this lobe could not be accounted for with the Hapke model. Removal of this lobe resulted in reasonable Hapke parameters (Table 1). We hypothesize that the presence of clay and micaceous minerals in non-random orientations (i.e. layered) are responsible for this behavior and the poor description by the Hapke model. Hapke assumes that particulates are equant and randomly oriented in his derivation and therefore an initial condition for the use of the model is not met. Reasonable solutions could not be found for the cobble site. In addition to the poor description of the underlying playa, we believe that variability in the cobble distribution and preferential shadowing of the playa by the cobbles are responsible for the model's failure. The lava flow could be modeled, but dubiously. Smaller variances in the data from the model fit were found for the lava flow but much of this is due to the darkness of the flow compared to the playa and cobble sites. Modeled roughness is low, 15°, compared with approximately 20-30° estimated from topographic profiles generated by helicopter stereophotography.

In conclusion, we have found the Hapke model to be inadequate for three relatively common geologic surfaces. The model is not at fault; rather, the complexity of most geologic surfaces is not accounted for in the initial assumptions.

Table I

	(0.66 μm)	(0.83 μm)	(1.66 μm)
single scattering albedo	0.982	0.986	0.981
roughness	13.4°	13.3°	10.8°
opposition surge amplitude	3.8	4.1	4.7
opposition surge width	0.114	0.131	0.071
asymmetry factor	0.704	0.714	0.810
variance	0.00012	0.00014	0.00017

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